GOOD PRACTICE GUIDE 273

Computerised routing and scheduling for efficient logistics

FREIGHT TRANSPORT ASSOCIATION

ENERGY EFFICIENCY

BEST PRACTICE PROGRAMME

COMPUTERISED ROUTING AND SCHEDULING FOR EFFICIENT LOGISTICS

This Guide is No. 273 in the Good Practice Guide Series. The Guide will help those involved in the distribution industry decide whether introducing computerised vehicle routing and scheduling technology will be worthwhile for them.

This Guide describes the types of computerised vehicle routing and scheduling systems available and the benefits of using them. Computerised delivery schedules are still not in widespread use in the distribution industry, particularly among smaller operators. However, those that are using them report improvements in operating efficiency, reduced fuel and administration costs and improved customer service.

By automating complex decision-making processes, computerised vehicle routing and scheduling systems will bring many benefits, e.g. optimising use of resources, reducing planning time often from days to hours, and make it easier to accommodate last-minute orders and re-evaluate routes rapidly, all of which will bring cost benefits.

Computerised vehicle routing and scheduling systems can be adapted to the needs of distribution networks, whether large companies making similar distributions every week, or companies where home delivery is the main business.

A sophisticated auto-scheduling system will be able to produce accurate, mapped routes, taking into account vehicles, drivers, compatible loads and customer delivery constraints – but even the most powerful decision support tool needs an experienced distribution professional to make it work.

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FOREWORD

This Guide is part of a series produced by the Government under the Energy Efficiency Best Practice Programme. The aim of the programme is to advance and spread good practice in energy efficiency by providing independent, authoritative advice and information on good energy efficiency practices. Best Practice is a collaborative programme targeted towards energy users and decision makers in industry, the commercial and public sectors, and building sectors including housing. It comprises four inter-related elements identified by colour-coded strips for easy reference:

— *Energy Consumption Guides:* (blue) energy consumption data to enable users to establish their relative energy efficiency performance;

— *Good Practice Guides:* (red) and *Case Studies:* (mustard) independent information on proven energy-saving measures and techniques and what they are achieving;

— *New Practice projects:* (light green) independent monitoring of new energy efficiency measures which do not yet enjoy a wide market;

— *Future Practice R&D support:* (purple) help to develop tomorrow's energy efficiency good practice measures.

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1 INTRODUCTION

1.1 Why use CVRS?

Computerised Vehicle Routing and Scheduling (CVRS) helps businesses to improve the utilisation of their transport resources. It can help to reduce journey times and vehicle mileage, reduce costs and improve the reliability of delivery schedules. This is achieved by rapidly processing the information concerning customer locations and quantities and types of goods to be transported and matching these to available vehicle capacity in order to make the best use of all resources.

In addition to resource and cost savings, users obtain substantial customer service benefits through improved reliability and environmental benefits through reduced mileage.

1.2 The purpose of this Guide.

This Guide contains:

- a summary of the benefits of using CVRS;
- quantification of actual benefits from a survey of CVRS users, plus more detailed individual Case Studies from companies that have successfully introduced this technology;
- an explanation of how the different types of CVRS work;
- guidance on the process of selecting and introducing CVRS.

The Guide is intended to help anyone engaged in distribution planning and considering using CVRS for the first time. However, it does not describe the features of individual products or compare their respective functionality and quality.

1.3 Who should use this Guide?

This Guide will be of use to:

- transport managers;
- logistics professionals;
- distribution planners;
- consultants;
- information technology experts.

Woodwards Foodservice

Traditionally, Woodwards had carried out its transport planning, routing and scheduling activity manually. Handling up to 1,200 deliveries/day at peak times and 5,500 customers put increasing pressures on the operation, and Woodwards turned to CVRS to provide the solution. Paragon for Windows was selected and it was first implemented at the Bodelwyddan depot in North Wales.

Paragon was interfaced with Woodwards' warehouse management, order processing and stock control systems. This enables Paragon to be used in the late afternoon to schedule the next day delivery operation, with delivery schedules from Paragon being passed seamlessly via the system interfaces to the warehouse for the overnight picking operation. As customer requirements and volumes change, or a particular delivery takes longer than expected, this information can be fed back into Paragon so that the schedules can be adjusted and fine tuned to ensure maximum operational efficiency and the planned schedules match real delivery requirements.

Introducing CVRS has:

- reduced planning time to create the delivery schedules;
- reduced the fleet of vehicles from 30 to 25;
- reduced daily vehicle mileage by 10%;
- increased picking/loading productivity by 50%;
- balanced load sizes more evenly enabling the planner to share out the work more efficiently;
- provided a modelling tool to carry out strategic planning and resource modelling.

Woodwards has now added three more depots to its original Bodelwyddan cold store, dramatically extended its geographic coverage, and doubled its fleet to 50. Using Paragon's multi depot upgrade to handle an increased number of daily deliveries, and the 'freezing route' option to release plans for early picking, Woodwards has cut mileage by 7,000 km/year and reduced driver hours by 81 a week.

2 SURVEY OF CVRS USERS

A postal survey of 2,300 Freight Transport Association (FTA) members was conducted in April 1998 in order to establish the extent to which CVRS had been adopted by the industry. Of the 600 respondents, 138 (23%) said that they were using some form of CVRS.

The responses were analysed to determine the breakdown by Standard Industry Classification (SIC). Results of this analysis are shown in Fig 1.

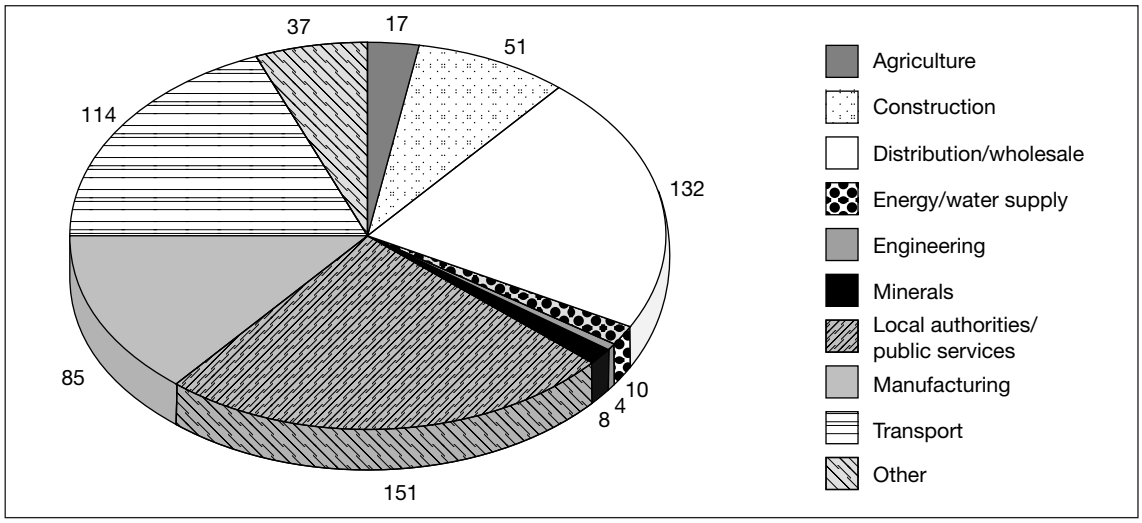


Fig 1 Breakdown of replies by industry sector

Fig 2 shows the analysis of the uses of CVRS by the respondents and Fig 3 the benefits they are obtaining.

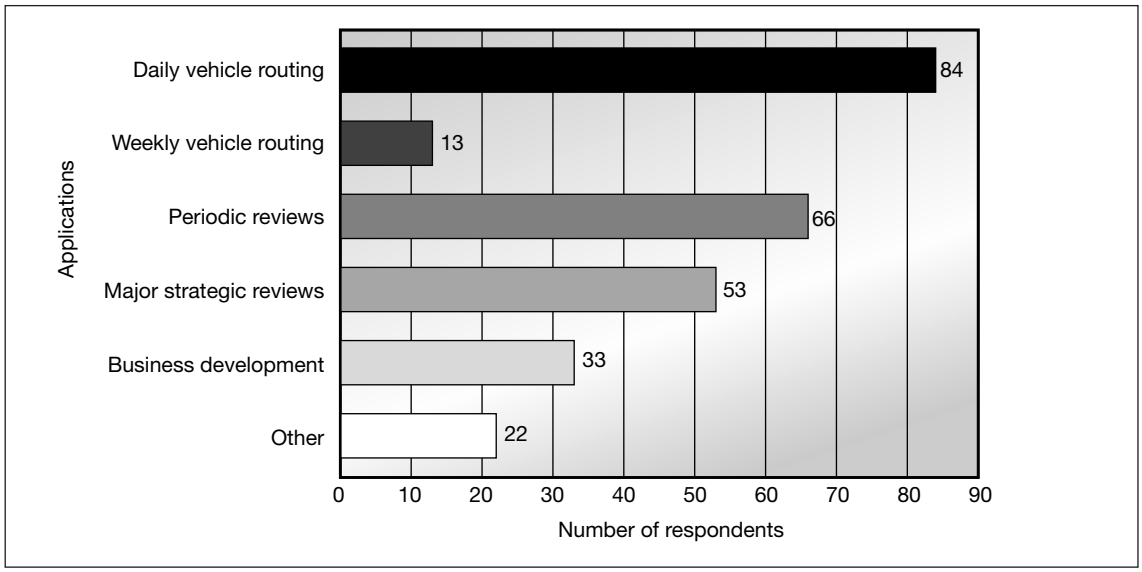


Fig 2 Users of CVRS (FTA survey)

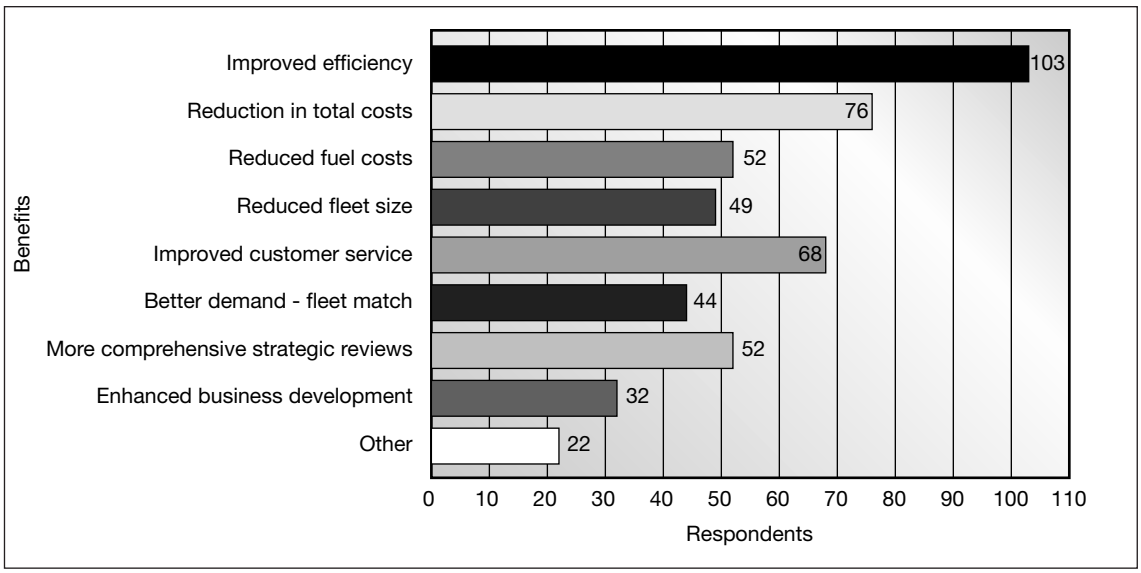


Fig 3 Benefits obtained from CVRS (FTA survey)

The main findings that emerged from the survey were:

- most users had improved operating efficiency as a result of using CVRS;
- 38% said that it had enabled them to reduce fuel costs;
- 49% had found it enabled them to improve customer service.

More detailed discussions took place with 17 users, who provided information from which Case Studies were developed. The main findings from this work were:

- 12 reported cost savings, of which five achieved reductions in operating costs of greater than 10%;
- 13 reported reductions in fuel costs, even though only one had this benefit in mind when installing the system;
- five quantified the fuel savings as over 10%;
- 11 reported reduced administration time;
- 12 reported reduced administration costs;
- 16 reported improved ability to meet time windows for deliveries.

A summary of the benefits reported by CVRS suppliers as having been obtained by some of their major users is given in Table 1.

Spicers Wholesale Ltd

Formed in 1796, Spicers Wholesale Ltd produces paper stationery products and diversified into the wholesale market in 1977. It has 12 distribution centres in the UK, five in France and one in Germany. The central distribution centre is a 650 acre site located in Cambridge. To improve the level of customer service, cut costs and reduce the size of the fleet, the company introduced an in-cab data collection system (Tourmaster) – a black box data information package – which is now interfaced with the Truckstops software the company uses. The benefits include:

- improved speed of operation;
- vehicles reduced by four at one depot;
- improved customer service;
- improvement of next day delivery;
- improved vehicle utilisation;
- consistent time and administration;
- average cost per drop reduced by 10%.

A – Cost reductions		
Wavin Building Products	-	reduced transport costs by 15%
Dalgety	-	reduced transport costs by 16 to 17%
Scottish Power	-	reduced transport costs by 10% and planning time by 50%
Henkel Iberica	-	reduced planning time by 50%
Panasonic	-	reduced transport costs by £6,000 to £8,000 per month
Spicers	-	made annual savings of £600,000
Initial UK	-	made annual savings of £1 million
B – Fleet reductions		
Magnet Joinery	-	reduced fleet size by six vehicles
Woodwards Food Service	-	reduced fleet size from 30 to 25 vehicles
C – Mileage reductions		
Magnet Joinery and Woodwards Food Service	-	reduced mileage by 10%
Safeway	-	reduced mileage by 18%
Armitage Shanks	-	reduced mileage by 20% over two years

Table 1 Examples of benefits achieved by CVRS users

3 TYPES OF CVRS SYSTEMS AND THEIR BENEFITS

There are two types of CVRS system: journey planners and the more sophisticated vehicle scheduling systems.

3.1 Journey planners

Journey planners are used for manual scheduling of single routes where the user decides the calls to be allocated to each journey and determines the best route and the best call sequence with the journey planner.

The cost of purchasing such software is considerably less than a vehicle scheduling system.

The journey planner can be a very effective tool for a user with a small fleet where the number of routes to be planned or the number of calls to be routed is small.

3.2 Vehicle scheduling systems

Vehicle scheduling systems process information about customer locations, quantities and types of goods, and match this information to available vehicle capacity in order to produce economic and viable routes.

They calculate the time required to complete the work and determine the resources required, using collection and delivery information and observing pre-determined parameter settings.

They can be used for dynamic daily or weekly planning and for strategic exercises. The operator can test alternative solutions, find the best one and can make manual adjustments where necessary.

A vehicle scheduling system is an appropriate tool for those operating fleets of 10 vehicles or more on multiple drop work where the scheduling task is complex. Those whose requirements are more straightforward (e.g. single drop haulage work) will find a journey planner quite satisfactory. Many users start by introducing a stand-alone journey planner and then progress either to integrating the journey planner into their sales order processing system or upgrading to a vehicle scheduling system.

Table 2 shows an example cost benefit analysis.

Table 2 Example cost benefit comparisons for CVRS

Current annual transport spend	£1,000,000
Fleet size (vehicles)	20
Depreciation period for CVRS investment	4 years
Set-up cost of CVRS	
Hardware	£2,500
Software	£20,000
Initial training	£2,000
Subtotal	**£24,500**
Annual recurring costs	
System updates	£2,000
Training on new system features	£1,000
Subtotal	**£3,000**
First year CVRS cost	£6,125
Annual CVRS cost for the next three years	£9,125
Annual cost savings (at 5% of transport spend)	£50,000
Annual cost savings (at 10% of transport spend)	£100,000
Payback period for initial investment (assuming 5% annual cost reduction)	6 months
Payback period for initial investment (assuming 10% annual cost reduction)	3 months

Most CVRS systems are the subject of continuing development, and existing features are improved and new features added. Normally, these enhancements are passed on to licensees as part of an annual service charge with regular upgrades (typically at six monthly or annual intervals).

3.3 The benefits of using CVRS

CVRS enables companies to use transport resources more efficiently, saving time, improving delivery predictability and reducing vehicle mileage and fuel consumption.

A comparison between the benefits, which can be expected from each type of CVRS system, is given in Table 3.

Table 3 Comparative benefits of both types of CVRS

Journey planners	**Automatic vehicle scheduling systems**
Reduced mileage	Reduced mileage
Reduced fuel use	Reduced fuel use Fewer vehicles Fewer drivers Reduced cost Reduced administration time Less manual data entry More economical routes
Slightly reduced planning time	Substantial reduction in planning time
Improved customer service	Improved customer service
An achievable route that gives shortest distance, shortest time or lowest cost but without the facility to observe time windows and other customer requirements	An achievable plan that ensures all deliveries are planned to meet time windows by taking account of resources available and producing the most efficient routes with improved load composition
Suggested collection and delivery times and best sequence for individual routes	More predictable and consistent collection and delivery times for multiple routes
Less overtime	Less overtime Less spot hiring Reduced lead time from order receipt to customer delivery
Some improvements in operational efficiency	General improvements in operational efficiency Ability to review plans to accept late orders Route revision at any time

Further benefits are:

- Users are able to centralise the planning process and reduce fleet size, reduce the number of depots, establish and review the profile of the fleet. They can also reduce the number of staff involved with the planning process or make more efficient use of the planner's time through reduced administration effort, paperwork and planning processes.

- Fuel costs will be reduced as a result of: reduced total mileage by planning more efficient routes; reduced empty mileage by better co-ordination of outbound and return loads; improved average miles per gallon as a result of planning to avoid known congestion 'hot spots' at particular times; and schedules that do not place unrealistic demands on the driver.

A vehicle scheduling system:

- Allows the distribution strategy to be reviewed regularly in line with changes in the business.
- Permits integration of different elements of the distribution operation. These could be functional (e.g. multiple drops, full load activity) or geographic (e.g. multiple depot operations).
- Permits integration and improvement of production planning and order processing.
- Eliminates manual tasks such as data entry and production of delivery documentation and reduces the risk of error.
- Enables customer lead time (within the distribution chain) to be reduced.
- Enables the performance of key parts of the logistics chain to be monitored separately using key cost drivers (such as drop density and volume).
- Facilitates innovative changes within the business, for example: service level differentiation (delivery next day, next day by a certain time); more frequent delivery; and more flexible use of resources

The benefits of CVRS systems are maximised when the software is integrated with other supply chain management computer software. (e.g. sales order processing and warehouse management). In the case of vehicle scheduling systems, picking lists and despatch notes can be produced along with key performance indicators for better control of the business.

Applications are now available that can link with mobile tracking systems and on board computers to provide 'real time' information on the location and progress of each vehicle and on road traffic conditions.

Fig 4 shows the benefits of vehicle scheduling systems.

3.4 The harder the planning task the greater the potential benefit

Factors that influence the complexity of the task are:

Vehicle resources
- The number of vehicles to be scheduled.
- The range of types and capacities of vehicles to be used.

Driver resources
- The number of driver shifts required.
- Limitations on the hours that drivers are able to work and drive.

Customer requirements
- The number of deliveries and collections required.
- The profile of customer time windows (i.e. some narrow and others wide).
- The number and spread of booked times.
- In a weekly plan, the collection or delivery day required.
- Constraints on the vehicle types that can be handled at individual call points.
- The existence of bulk consignments (i.e. single orders for one customer exceeding the capacity of the largest vehicle).

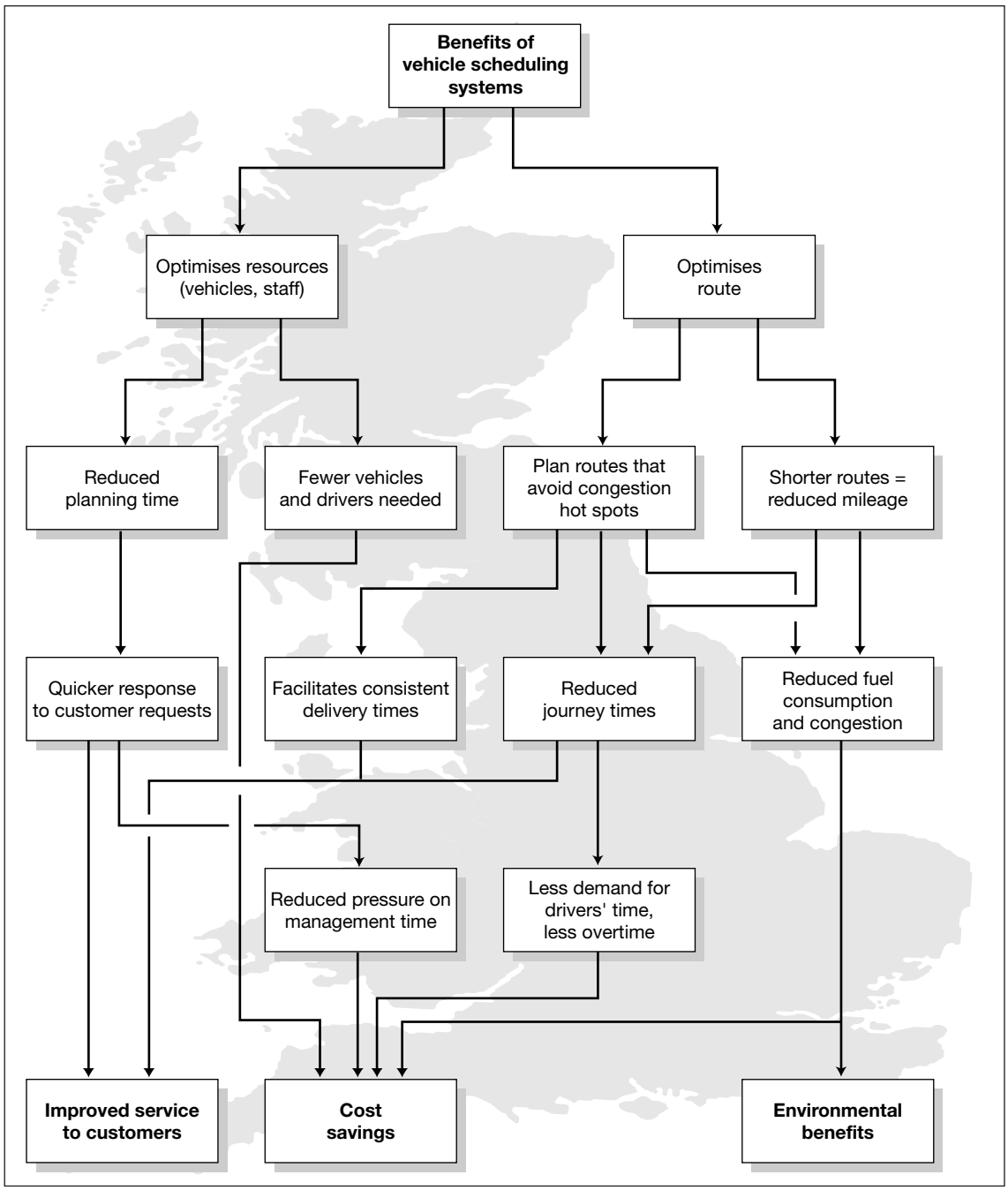


Fig 4 The benefits of vehicle scheduling systems

Operational factors

- The need for goods to be carried in vehicles with multiple compartments (e.g. tankers, ambient/chilled/frozen).
- Restrictions on product compatibility affecting the ability of different products to be carried in the same vehicle.
- The number of trips required per shift.
- In multiple depot operations, constraints on which customers can be served from which depots.
- The need to schedule night trunking work and depot delivery work.
- The range of products with varying weights, cubic capacities and characteristics.

Most vehicle scheduling systems have features that are capable of taking the above factors into consideration when planning routes.

Rank Hovis

Rank Hovis' operation is run from a central office at Southampton for deliveries across southern England and South Wales. The company delivers 'Bag & Bulk' products to group, supermarket and small bakery customers. Its transport and warehousing contract is run by Wincanton Logistics.

InterRoad is used to route all bag, palletised deliveries. This consists of approximately 500 deliveries/week from various depots, including Southampton, Plymouth, Worcester, Bedford and Purfleet. The majority of customers require a delivery between the hours of 0600 and 1200, and many have stringent access restrictions.

Roadshow is used to route each day's orders by splitting the country up into zones or 'territories' and associating a depot with the orders in that territory. From all the set-up parameters for the customer, Roadshow then gives a routing suggestion.

Through a rescheduling project, £250,000 has been saved out of a £4M budget – a 6% reduction. Improvements in customer service include:

- lower paperwork errors;
- more consistent routing;
- greater traceability.

4 MAPPING

All CVRS systems use some form of electronic mapping. The map is an integral part of CVRS, can directly affect the quality of the solutions produced and is a major area of difference between the various systems.

Computer mapping technology is becoming extremely sophisticated and vector maps are now available that can show street level detail in all towns, simply by zooming in to magnify selected areas. Such detail is essential for accurate routes in dense urban areas on multiple stop journeys, to retail or industrial premises, or for home deliveries (e.g. for goods ordered via the Internet).

For national distribution where routes normally cover much wider geographic areas, such accuracy is not always necessary and more generalised calculations are usually acceptable based on principal roads only.

Some suppliers, whose standard maps do not provide street level detail, will prepare customised maps for selected geographic areas at a supplementary charge.

For international distribution, maps are becoming available for groups of countries, for individual countries or for sections of countries.

Most CVRS systems calculate distance and time by plotting routes against the electronic road map and calculating the journey time by applying appropriate speeds for the categories of roads included on the route.

Some systems use an integral time and distance matrix (i.e. the shortest time and distance between a master set of pre-determined locations) to calculate distance and time. The ‘straight line’ distance is determined by the system, and distance and time is computed by applying a user-defined ‘deviation factor’ – typically +25% or +30% to allow for the curvature of the path of the roads. The user can set these factors to suit the customer database.

5 JOURNEY PLANNERS

5.1 Purpose

The principal purpose of journey planners is to calculate time, distance and cost for individual journeys. However, they do not permit the user to take account of customer loading and unloading constraints (e.g. time windows, booked time or vehicle size).

5.2 Applications

Typical applications for journey planners are:

- calculation of time, distance and cost of manually generated routes;
- preparation of haulage quotations;
- checking distance shown on driver tachograph charts;
- validation of haulage invoices;
- establishing the daily driving range of certain types of vehicle;
- reducing mileage by finding the shortest route;
- producing journey itineraries for use by drivers;
- checking the time and distance range from given operating centres;
- comparing direct (radial) miles with actual road miles over specified routes.

5.3 Operation

Journeys are calculated electronically by locating points of call on a journey, plotting distance between node points and displaying the route on the digitised map. The user can normally choose whether the journey is calculated on:

- least time;
- least distance;
- least cost.

The user can also choose whether journey time should be calculated on a pre-determined departure time or a pre-determined arrival time. Fig 5 summarises the process of using a journey planner to optimise route.

5.4 Data input

In a journey planner, the initial creation of journeys is a manual process. This type of CVRS is, therefore, not suitable for planning numerous routes or routes with numerous call points as the planning process will be very time consuming. When building journeys, each call point must be identified (by post code, town name or grid reference) and entered. Planning time can be reduced if journeys are saved to disk and later recalled for modification.

It will enable efficiency to be improved, energy consumption to be reduced and costs to be reduced without major software investment.

The maximum number of call points that can be included on a journey varies according the system (or system version) used. Generally, the lower the maximum number of call points permitted on each route the lower the cost of the software. The range is typically from 10 to 99 depending on the system chosen.

Individual call points can be added, deleted or edited on individual routes by selecting a point on the map.

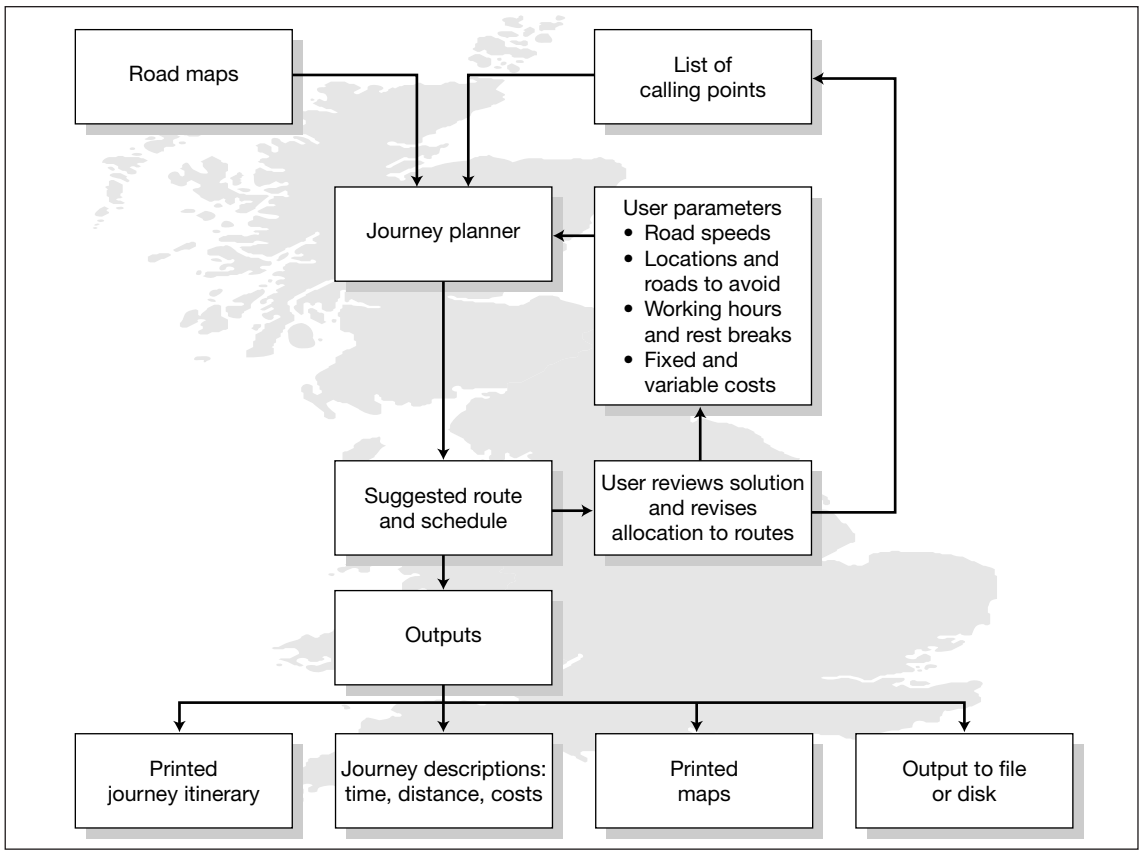


Fig 5 Summary of the journey planning process

5.5 Verification of addresses

Verification of addresses is normally carried out within the system. The user must check the location suggested by the system in relation to their knowledge of the call point locations. Systems normally locate to town, post code sector or grid reference. The accuracy of location is dependent on the degree of sophistication of the address verification and mapping levels within the system. For greater accuracy, independent verification systems can be used, but this approach is normally associated with the use of the more sophisticated vehicle scheduling systems (Section 6).

Most gazetteers contain 40,000 to 50,000 place names – sufficient for most purposes. Some systems provide the facility to create a user-defined gazetteer.

5.6 Parameter settings

Most journey planners permit the user to define the following parameters. However, care must be taken to avoid using unrealistic settings, which could result in unachievable journey times.

- Type of vehicle to be used.
- Running speeds by category of road for each vehicle type.
- Percentage reduction in speed over selected sections of roads or whole roads.
- Length of rest periods and breaks.
- Peak/off peak and night-time bands and percentage speed variation during those time bands.
- Any towns to be avoided by a specified radius.
- Any roads or sections of roads not to be used.
- Duration of stop time (for individual deliveries or collections).
- Fixed cost per day and per hour for each vehicle type.
- Variable running costs per mile or per kilometre for each vehicle type.

Changing the settings listed above normally affects all routes.

5.7 Screen mapping features

Individual journeys can be displayed on screen against a background of the road network. If desired, the user can choose to display parts of a route in more detail by selecting smaller areas of the map to appear on the screen.

5.8 Other features

The following features are normally available on route planners:

- Finding the nearest place or road by placing the cursor on the map.
- Optimising the sequence of calling points within multiple stop journeys. This feature is particularly helpful when the user is unsure of the best sequence for particular journeys or has built them up from orders received throughout the day. This feature is also useful for quickly reorganising journeys to accommodate additional last minute orders.
- Time allowances for short sea crossings (ferries and tunnels). These are usually set by the software supplier and are normally based on an estimated average crossing time including terminal allowances.

5.9 Outputs

- Individual journeys can be saved to file and recalled later for printing and/or amendment.
- Maps can be printed (colour or black and white).
- Detailed journey itinerary for issue to drivers etc.
- Summary of journey showing total time, total miles and total cost.

Fig 6 shows a route map from a journey planner.

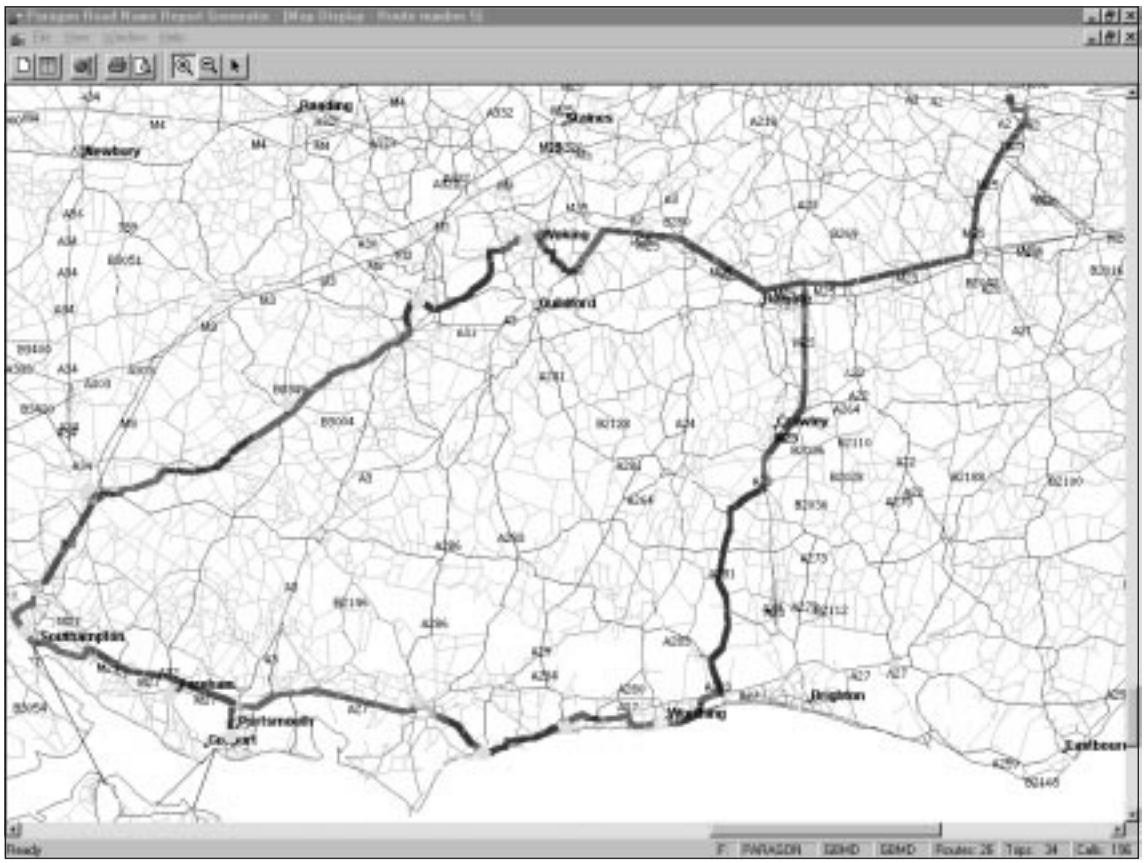


Fig 6 Example of a journey map

6 VEHICLE SCHEDULING SYSTEMS

6.1 Purpose

The main purpose of vehicle scheduling systems is to help the distribution planner to produce rapid and accurate computations of vehicle routes for large numbers of calls taking into account external factors such as vehicle access constraints and customer time windows. The computations take into account a wide range of user-defined and pre-determined parameters, so as to use the minimum possible level of transport resources.

Vehicle scheduling systems allocate the calls each vehicle makes to suggested computer-generated routes. The system user can make on screen changes and test their effect on service levels and distribution costs.

A vehicle scheduling system is, therefore, a sophisticated decision support tool and will produce the best results when used by a distribution planner with experience in manual planning techniques. It is not a 'black-box' system to be relied upon to produce solutions without human intervention.

The key to successful use of the system is a thorough understanding of the distribution planning process and the software being used. This will ensure the production of consistent solutions with acceptable and efficient routes, thereby reducing the need for time consuming manual adjustment.

6.2 Applications

Vehicle scheduling systems are used in three main ways.

6.2.1 *Operational*

- Dynamic daily scheduling.
- Weekly scheduling.
- Validation and/or optimisation of existing manually planned routes.
- Testing the effect on resources and costs by varying parameters and assumptions (i.e. 'what if' questions).

Dynamic daily scheduling can produce major cost benefits – particularly for operations where there is no regular daily delivery pattern (e.g. home deliveries). Weekly scheduling is more appropriate for supply chains, where the distribution planner is aware of the anticipated delivery requirements for at least one week ahead.

6.2.2 *Strategic*

- Planning resource requirements and budgeting for forecast business, seasonal variations in demand, and new/revised regional depot structures.
- Evaluation of alternative options (e.g. comparing cost effectiveness of in-house and third party distribution strategies).
- Scheduling from multiple depots (either with calls assigned to particular depots or with the system free to allocate calls to the depots in the most cost-effective manner).

6.2.3 *Commercial*

- Preparation of tender submissions by third party contractors.
- Consultancy studies designed to seek the most cost-effective method of providing the desired level of customer service on behalf of clients.

6.3 Operation

The powerful capabilities of the software include the ability to:

- Reduce costs by minimising resource requirements, i.e. number of vehicles and drivers for a given workload.
- Determine the most appropriate depot from which to schedule specific calls.
- Observe all customer access constraints (e.g. closed days, vehicle size and type restrictions, delivery time windows and customer booked times).
- Reduce loaded and empty mileage.
- Accommodate collections and deliveries en route without exceeding payload tonnes, available load space or drivers' hours limits.

Safeway

Safeway has used Paragon to plan its complex nationwide delivery operation for 15 years. Today, the operation involves multiple daily deliveries of fresh, frozen and ambient products using a fleet of 600+ tractor units and 1,000+ trailers to Safeway's 480 stores. Paragon has been implemented in each of the 10 major depots to generate fixed route schedules for each day (revised to reflect actual order volumes), for seasonal planning (Christmas and summer peaks), for strategic analysis of the distribution operation and for performance monitoring.

The benefits obtained through the introduction of CVRS are:

- reduced overall fleet strength, typically by 10 – 15%;
- reduced km's travelled;
- improved driver productivity;
- improved service levels, formulating delivery windows and ensuring they are met;
- strategic and tactical planning applications – managing a complex transport network.

Paragon is also interfaced with Logiq – the system Safeway is using for in-cab monitoring. Information is downloaded from Logiq's on-board computers using smart cards, containing route plans from Paragon, which record data on actual driver performance. This provides transport managers with a tool to identify and target areas of poor productivity.

Integrating the two systems allows Safeway to:

- create a streamlined system encompassing planning, loading, despatch and delivery, with full performance monitoring and single-source management information;
- monitor actual performance against the Paragon plan;
- target areas of poor productivity;
- deliver improved service standards to stores and consumers through a new level of control.

6.4 Data input

To ensure good results are obtained from vehicle scheduling systems it is essential to establish an efficient and accurate method by which information can be imported into the system from external sources. It is highly desirable to avoid manual input if at all possible.

The vehicle scheduling system accepts data from external sources including other computer databases (e.g. addresses from a customer database and order quantity from a sales order processing system). A summary of the operation is given in Fig 7.

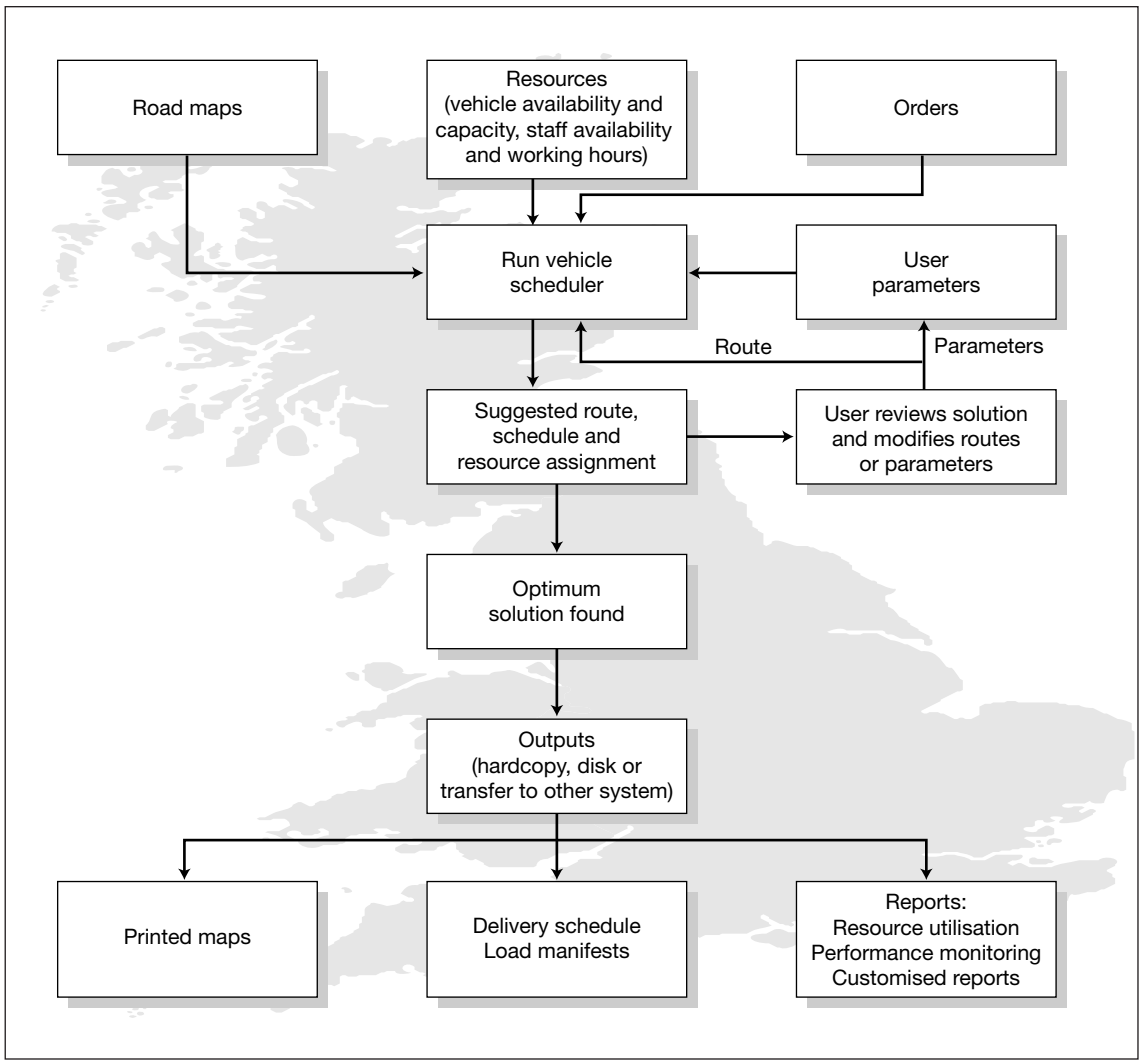


Fig 7 The automatic scheduling process

6.4.1 *Customer location data*

To use a vehicle scheduling system, the distribution planner will need to provide the following data:

Essential

- **Unique reference number.** Required to enable the computer system to identify correctly the delivery or collection location.
- **Name.** Company name, delivery town or customer reference number can be used.
- **Address.** Post-code, town name or grid reference. The more accurate the location data, the more accurate will be the solution produced.

Optional

- **Specified delivery day.** Some customers always receive their deliveries on a specified delivery day each week. Including this information ensures that the vehicle scheduling system will always plan the delivery on the correct day. If delivery day is not specified, the system will determine the most economic day on which the delivery can be made with a given resource.
- **Specified time windows.** Some customers may receive their deliveries within one or more specified delivery time windows. Including this information ensures that the vehicle scheduling system will always respect these times. Systems vary considerably in the number of time windows available. Some provide two per day, while others give an almost unlimited range of options with different time windows available on different days of the week.

- **Specified vehicle types.** Certain customers may wish to receive their deliveries on the same type of vehicle every time, possibly due to height, length, or weight restrictions. Setting the vehicle type will ensure that the correct type of vehicle is always used.
- **Scheduling from specified depots.** In many multiple depot operations, the depot from which particular calls are to be served is largely pre-determined. Specifying the depot to be used for particular customers enables the vehicle scheduling system to observe these requirements.
- **Pre-planned routes.** Many distribution operations are characterised by weekly or daily pre-planned routes. Allocating specific route numbers to particular customers ensures that the vehicle scheduling system will always attempt to plan the orders for a given customer on the predetermined route.

6.4.2 *Customer order data*

Essential

- **Unique reference number.** This must be cross-referenced to the unique customer location reference. Order numbers must be unique to each fresh order for a particular customer.
- **Order quantity.** Order quantities can be imported for a range of product types by weight or volume.
- **Delivery or collection.** Vehicle scheduling systems must be able to distinguish between deliveries and collections. Collections will only be planned if there is room on the vehicle at that point on the route.

Optional

- **Sequence of delivery.** Orders can be scheduled in a particular sequence on pre-allocated routes provided a sequence number is attached to each order. This feature can only be used in conjunction with pre-planned routes.
- **Priority.** Provided this is included, particular orders can be assigned different priorities. Some systems automatically update the priority of orders remaining undelivered at the end of each day.
- **Booked time.** Specifying a booked delivery/collection time enables the user to plan routes so as to ensure that all timed deliveries and collections can be met.
- **Loading and unloading time.** All systems permit the user to set allowances for loading and unloading time. Different values can be used for different product types or different vehicle types. Some systems also permit different times to be used on different vehicle types or on different days of the week.
- **Tramping.** Not all systems incorporate this feature. It permits routes to be planned for collection of orders from one point *en route* and delivery to another without returning to the depot. It also enables routes to be created that visit several depots without returning to base. It is normally necessary to complete specific information fields to enable the system to link the orders that are to be scheduled using this feature.
- **Bulk products.** Some systems enable orders larger than the largest capacity vehicle to be assigned to several vehicles of appropriate sizes. This feature can be particularly useful for individual orders of very large quantities.
- **Revenue details.** Some systems allow the user to import transport revenue details with order data. This can be expressed in a variety of ways (e.g. per order, per pallet, per kilogram, per litre).

6.4.3 *Data entry and importation options*

Rapid data importation is possible with one of the following standard data file formats:

- ASCII Text, e.g. Comma Separated Variable (CSV) or Print (PRN).
- Microsoft Excel spreadsheet versions (XLS).
- Lotus spreadsheet versions (WK3, WK4 etc.).
- Rich text format (RTF).

Although it is possible to enter data manually, directly into the vehicle scheduling system, this is a rare practice as it is vastly more time consuming than electronic importation through a spreadsheet package or via direct computer link.

Where users have a mainframe order processing system, establishing a direct link to the vehicle scheduling system will improve accuracy and save time.

A key factor for successful use of a vehicle scheduling system is accuracy in the preparation and validation of the data prior to importation. Any small discrepancy in the data will be highlighted by the system and cause rejections at the importation stage or, worse still, failures when scheduling.

6.5 Verification of addresses

Some systems use an internal address to accurately pinpoint customer locations. Others require the user to verify customer addresses using another software product.

Companies dealing with different customers every day should not regard setting up address data as an insurmountable problem as there are many examples of companies using CVRS for planning home delivery operations.

Address information can be imported in several ways.

6.5.1 *Postcode*

This the most popular method and is the most accurate readily available location reference. Most users should easily be able to obtain post codes for their collection and delivery points, but if this is not possible, systems are now available that permit post codes to be readily identified from address data prior to importation.

Many vehicle scheduling systems can interpret postcode information down to full postcode level. This will map the call point to within a 100-metre grid in both urban and rural areas, thus giving a high degree of accuracy. Schedulers that are only capable of locating to postcode sector level (e.g. TN49) do not provide such a level of accuracy, but for many users this will be satisfactory.

6.5.2 *Grid reference*

Locating by grid reference or by latitude and longitude is extremely accurate, particularly for deliveries and collections for the agricultural sector. However, errors in grid references are difficult to detect without supporting address information.

6.5.3 *Gazetteer*

Although this is a reasonably accurate method of identifying call point locations, it has some weaknesses. The main weaknesses of using the gazetteer as a means of locating call points are:

- ambiguous place names;
- incorrectly spelt place names;
- vague location within large cities.

6.6 Parameter requirements

The user is able to set parameters to suit each operation. The structures of parameter files vary according to the system, but they normally fall into three main groups:

- data parameters;
- scheduling parameters;
- advanced parameters.

Typical data parameters include:

- general (company name, distance unit, percentage of standard speeds, minimum time and distance between calls, closed days);
- load related (load unit, fixed/minimum/maximum call time);
- driver related (legal driving limits, break and rest periods, shift length);
- shift related (start and finish times, hourly payment rates, minimum shift cost, overnight allowance);
- vehicle types (access group, load capacity, depot time allowances, percentage of speeds and loading rates, fixed and running costs);
- product related (product type, product units per load unit, loading and unloading time, revenue);
- depots (location, opening times, throughput capacity, closed days).

Typical scheduling parameters include:

- scheduling period in days (maximum period ranges from seven days to several months dependent on the system);
- number of overnight stops permitted;
- number of trips per route (i.e. the maximum times the vehicle can return to a depot on any route);
- including collections at end of route;
- whether the fleet is fixed;
- number of vehicles and drivers at each depot (with a fixed fleet);
- vehicle/driver departure times.

Typical advanced parameters include:

- multiple depot;
- depot zones – allocates particular tasks to particular depots;
- tramping – allows collections and deliveries between intermediate points en route;
- deviation and cluster settings – these affect the grouping of calls on a particular route and the degree to which the vehicle can be permitted to deviate from the most direct route in order to make additional calls;
- optimisation settings instructing the computer as to the method of optimisation to use (e.g. time, distance, cost).

To ensure that the best solutions are obtained, the software supplier provides advice as to any advanced parameter settings or 'fine tuning' of parameters and system set up that may be required for particular operations.

6.7 Optimising use of resources with a vehicle scheduling system

6.7.1 *Rescheduling*

This is the scheduling option that will normally produce the most efficient and economic routes. Computer processing time varies according to the quantity of data to be handled, the degree to which the problem is constrained by delivery times or vehicle types, and the processing capacity of the hardware used.

6.7.2 *Viewing the reasons for calls not routed*

Invariably, the system will fail to schedule some calls. There can be many reasons for this, including:

- there may not be enough vehicles of the correct type;
- the collection or delivery point may be beyond the range of the vehicles available;
- there may not be enough driving or duty time;

- booked time constraints or time windows may conflict for calls planned on the same fixed routes;
- there may be insufficient time to complete certain calls within the shift time allowed.

The planner must be able to establish the reasons for any failures quickly. Some applications display the reasons for calls not planned, allow the user to make adjustments to particular routes and display any constraints that would be broken as a result of the manual alterations.

6.7.3 *Adding previously unscheduled tasks to existing routes*

This is a valuable feature for dynamic daily routing. It enables the planner to insert additional last-minute orders onto routes planned earlier in the day and to re-evaluate the routes rapidly.

6.7.4 *Creating new routes for previously unscheduled tasks*

This function is particularly beneficial when determining the number of additional short-term hire vehicles that may be required to handle a given volume of goods.

6.7.5 *Making manual adjustments to the computer generated solution*

Although vehicle scheduling systems can process large amounts of data quickly and efficiently, to ensure that maximum benefit is obtained, they should always be used by an experienced distribution professional. The user will need to have access to a fast and effective interactive capability so that the routes generated by the computer can be adjusted to reflect his or her knowledge of operational circumstances.

All systems have this capability, but some are more user-friendly in this respect than others. Examples of the interactive features provided are:

- The planner is normally able to modify routes by: changing the despatch day, inserting or deleting calls, re-sequencing calls, inserting break periods and rest periods, inserting depot visits and additional deliveries, and modifying the resources used (i.e. depot, vehicle and driver shift). There is normally a facility to re-optimise routes after making interactive modifications.
- Some systems now permit the user to move calls between routes by using the mouse to “drag and drop” from the map display and to view the effects of these changes on operating restraints.

6.7.6 *Merging routes*

Occasionally, the vehicle scheduling system produces routes that make poor use of the driver’s time, or vehicle capacity, or both. The systems normally permit the user to merge them interactively, thus further improving the use of resources.

6.8 Specialised scheduling applications

Specialised applications are available for more advanced tasks. Examples are listed below.

6.8.1 *Determining the optimum location for depots*

Separate modules are available from the principal suppliers of vehicle scheduling systems that enable the optimum locations for depots to be determined. They work by zoning the delivery points and finding the best location for a depot to serve each zone, taking into account the road network and the distribution of collection and delivery points within a given area.

6.8.2 *Integrated scheduling of fleets from several depots*

Some operators need to plan more than one fleet from different centres so as to achieve optimum utilisation of the resources available at each centre. One supplier has developed an option that enables the operation of a number of production units and fleets to be planned together so as to achieve optimum resource utilisation across all the operating centres.

6.8.3 *Multiple compartments*

This is a commonly available option for tanker operations. Particular quantities of product are assigned to particular compartments on particular vehicles ensuring that incompatible products

are not mixed on the same vehicles. Applications are also available for multiple compartment temperature controlled vehicles.

6.8.4 *Planning for market growth*

Some systems now permit the user to vary selected orders or all orders by a given percentage. This feature can be used when planning for increase or decline in business activity.

6.8.5 *Trunking and transhipment*

Some logistics supply chains (such as newspaper and magazine distribution by wholesalers) require the facility to plan direct deliveries and the ultimate delivery arrangements for goods transhipped at intermediate points on routes from the transhipment centre.

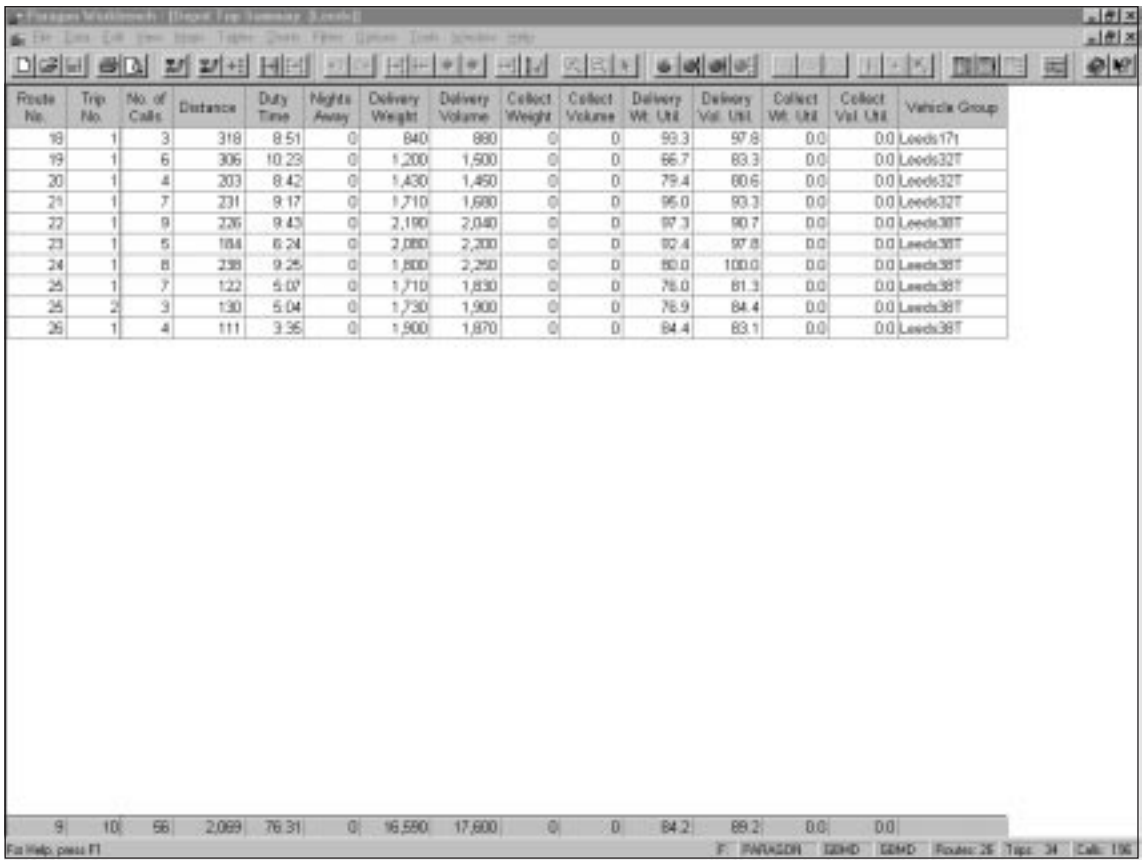
Others require the facility to plan primary trunking routes and secondary distribution routes according their own specific criteria. These features are available on certain vehicle scheduling packages and can result in considerable savings in planning time.

6.9 Outputs and reports

The reporting capabilities of modern vehicle scheduling systems are considerable, and modern systems allow the user to configure customised reports using external software applications. Examples of outputs and standard reports include:

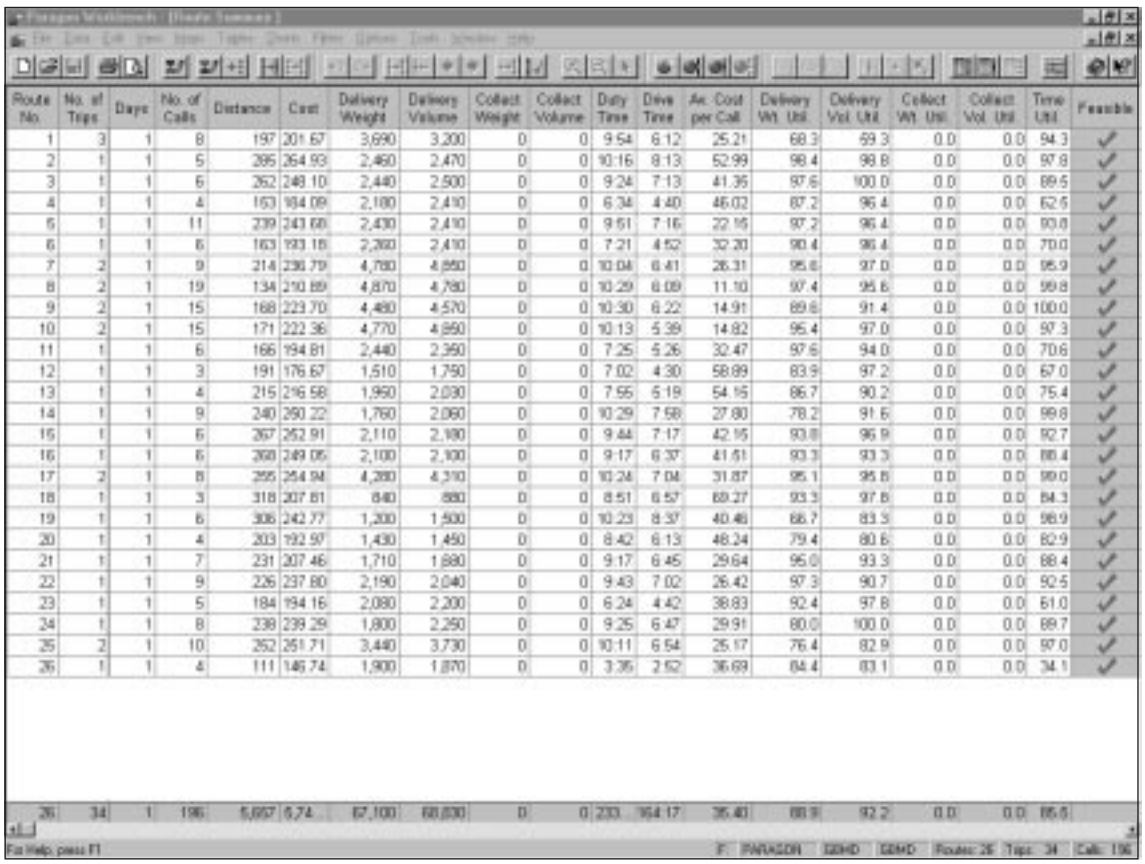
- printed maps (available in colour or monochrome);
- route reports (screen and print);
- standard resource utilisation and cost reports (screen, print and file);
- customised reports (screen, print and file);
- load manifests or daily traffic sheets showing the allocation of drivers and vehicles to routes;
- performance monitoring reports (comparing actual results with planned);
- route summaries showing distance, time, calls, quantity and cost;
- despatch reports showing run despatch and return date/time;
- resource utilisation bar charts showing the time spent on driving, other duties, break periods and rest periods in different colours;
- time utilisation summaries showing the proportion of time spent on different activities;
- profit and loss reports (for individual orders or for individual routes);
- cost per order delivered.

These reports can be exported to spreadsheet or database applications (e.g. Excel, Lotus123, Access or Lotus Approach), enabling the user to embed them into other reporting systems or adjust the content and appearance of the report. Systems that support Open Database Connectivity (ODBC) facilitate the integration of vehicle scheduling systems into the user's own corporate computer software environment.



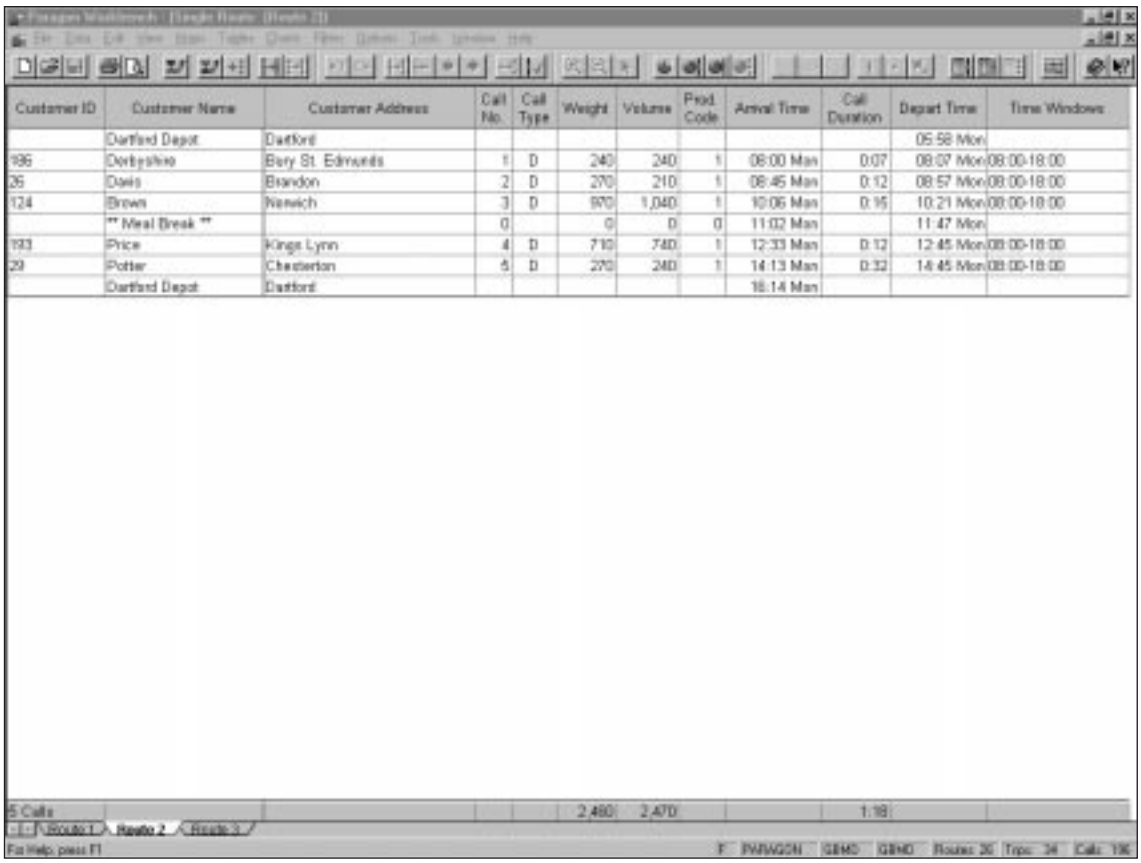
Route No.	Trip No.	No. of Calls	Distance	Duty Time	Nights Away	Delivery Weight	Delivery Volume	Collect Weight	Collect Volume	Delivery Wt. Util.	Delivery Vol. Util.	Collect Wt. Util.	Collect Vol. Util.	Vehicle Group
18	1	3	318	8.51	0	840	880	0	0	93.3	97.8	0.0	0.0	Leeds17t
19	1	6	306	10.23	0	1,200	1,500	0	0	66.7	83.3	0.0	0.0	Leeds32T
20	1	4	203	8.42	0	1,430	1,450	0	0	79.4	80.6	0.0	0.0	Leeds32T
21	1	7	231	9.17	0	1,710	1,680	0	0	95.0	93.3	0.0	0.0	Leeds32T
22	1	9	226	9.43	0	2,190	2,040	0	0	97.3	90.7	0.0	0.0	Leeds38T
23	1	5	184	6.24	0	2,080	2,200	0	0	92.4	97.8	0.0	0.0	Leeds38T
24	1	8	238	9.25	0	1,800	2,250	0	0	80.0	100.0	0.0	0.0	Leeds38T
25	1	7	122	5.07	0	1,710	1,830	0	0	76.0	81.3	0.0	0.0	Leeds38T
25	2	3	130	5.04	0	1,730	1,900	0	0	76.9	84.4	0.0	0.0	Leeds38T
26	1	4	111	3.36	0	1,900	1,870	0	0	84.4	83.1	0.0	0.0	Leeds38T
9	10	56	2,069	76.31	0	16,590	17,600	0	0	84.2	89.2	0.0	0.0	

Figs 8a Example of a depot trip summary



Route No.	No. of Trips	Days	No. of Calls	Distance	Cost	Delivery Weight	Delivery Volume	Collect Weight	Collect Volume	Duty Time	Drive Time	Av. Cost per Call	Delivery Wt. Util.	Delivery Vol. Util.	Collect Wt. Util.	Collect Vol. Util.	Time Util.	Feasible
1	3	1	8	197	201.67	3,690	3,200	0	0	9.54	6.12	25.21	68.3	69.3	0.0	0.0	94.3	✓
2	1	1	5	285	264.93	2,460	2,470	0	0	10.16	8.13	52.99	98.4	98.8	0.0	0.0	97.8	✓
3	1	1	6	262	248.10	2,440	2,500	0	0	9.24	7.13	41.35	97.6	100.0	0.0	0.0	89.5	✓
4	1	1	4	163	184.09	2,180	2,410	0	0	6.34	4.40	46.02	87.2	96.4	0.0	0.0	62.5	✓
5	1	1	11	239	243.68	2,430	2,410	0	0	9.51	7.16	22.15	97.2	96.4	0.0	0.0	93.8	✓
6	1	1	6	163	193.18	2,260	2,410	0	0	7.21	4.52	32.20	90.4	96.4	0.0	0.0	70.0	✓
7	2	1	9	214	236.79	4,760	4,850	0	0	10.04	6.41	26.31	95.6	97.0	0.0	0.0	95.9	✓
8	2	1	19	134	210.89	4,870	4,780	0	0	10.29	6.09	11.10	97.4	95.6	0.0	0.0	99.8	✓
9	2	1	15	168	223.70	4,480	4,570	0	0	10.30	6.22	14.91	89.6	91.4	0.0	0.0	100.0	✓
10	2	1	15	171	222.36	4,770	4,860	0	0	10.13	5.39	14.82	95.4	97.0	0.0	0.0	97.3	✓
11	1	1	6	166	194.81	2,440	2,360	0	0	7.25	5.26	32.47	97.6	94.0	0.0	0.0	70.6	✓
12	1	1	3	191	176.67	1,510	1,750	0	0	7.02	4.30	58.89	83.9	97.2	0.0	0.0	67.0	✓
13	1	1	4	215	216.58	1,950	2,030	0	0	7.55	5.19	54.15	86.7	90.2	0.0	0.0	75.4	✓
14	1	1	9	240	250.22	1,760	2,060	0	0	10.29	7.58	27.80	78.2	91.6	0.0	0.0	99.8	✓
15	1	1	6	267	252.91	2,110	2,180	0	0	9.44	7.17	42.15	93.8	96.9	0.0	0.0	92.7	✓
16	1	1	6	268	249.05	2,100	2,100	0	0	9.17	6.37	41.51	93.3	93.3	0.0	0.0	88.4	✓
17	2	1	8	255	254.94	4,280	4,310	0	0	10.24	7.04	31.87	95.1	95.8	0.0	0.0	99.0	✓
18	1	1	3	318	207.81	840	880	0	0	8.51	6.57	69.27	93.3	97.8	0.0	0.0	84.3	✓
19	1	1	6	306	242.77	1,200	1,500	0	0	10.23	8.37	40.46	66.7	83.3	0.0	0.0	98.9	✓
20	1	1	4	203	192.97	1,430	1,450	0	0	8.42	6.13	48.24	79.4	80.6	0.0	0.0	82.9	✓
21	1	1	7	231	207.46	1,710	1,680	0	0	9.17	6.45	29.64	95.0	93.3	0.0	0.0	88.4	✓
22	1	1	9	226	237.80	2,190	2,040	0	0	9.43	7.02	26.42	97.3	90.7	0.0	0.0	92.5	✓
23	1	1	5	184	194.16	2,080	2,200	0	0	6.24	4.42	38.83	92.4	97.8	0.0	0.0	61.0	✓
24	1	1	8	238	239.29	1,800	2,250	0	0	9.25	6.47	29.91	80.0	100.0	0.0	0.0	89.7	✓
25	2	1	10	252	251.71	3,440	3,730	0	0	10.11	6.54	25.17	76.4	82.9	0.0	0.0	97.0	✓
26	1	1	4	111	146.74	1,900	1,870	0	0	3.36	2.52	36.69	84.4	83.1	0.0	0.0	34.1	✓
26	34	1	196	5,697	6,74	67,100	68,830	0	0	233	164.17	35.40	88.9	92.2	0.0	0.0	85.6	

Figs 8b Example of a management summary



Customer ID	Customer Name	Customer Address	Call No.	Call Type	Weight	Volume	Prod. Code	Arrival Time	Call Duration	Depart Time	Time Windows
	Dartford Depot	Dartford								05:58 Mon	
186	Derbyshire	Bury St. Edmunds	1	D	240	240	1	08:00 Mon	0:07	08:07 Mon	08:00-18:00
26	Davis	Brandon	2	D	270	210	1	08:45 Mon	0:12	08:57 Mon	08:00-18:00
124	Brown	Norwich	3	D	970	1,040	1	10:06 Mon	0:15	10:21 Mon	08:00-18:00
	** Meal Break **		0		0	0	0	11:02 Mon		11:47 Mon	
193	Price	Kings Lynn	4	D	710	740	1	12:33 Mon	0:12	12:45 Mon	08:00-18:00
29	Potter	Chesterton	5	D	270	240	1	14:13 Mon	0:32	14:45 Mon	08:00-18:00
	Dartford Depot	Dartford						16:14 Mon			

Figs 8c Example of a route manifest

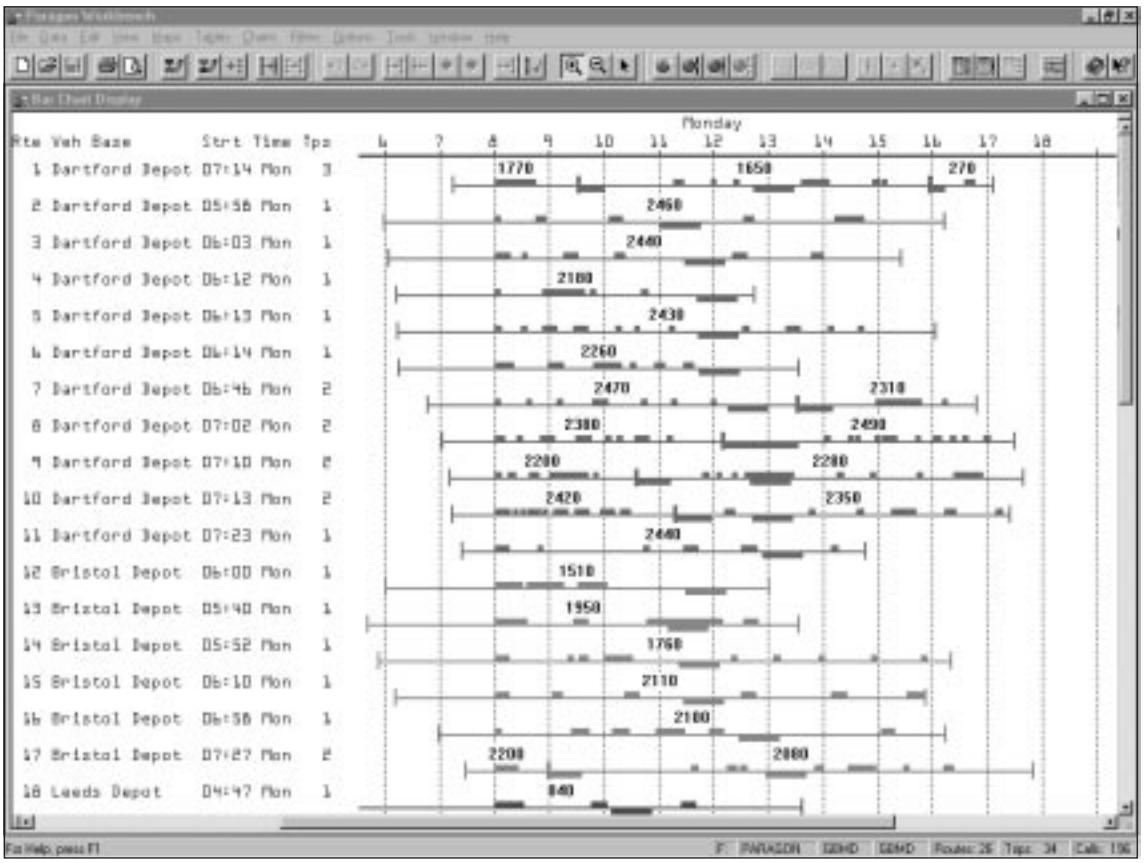


Fig 9 Example of resource utilisation bar chart

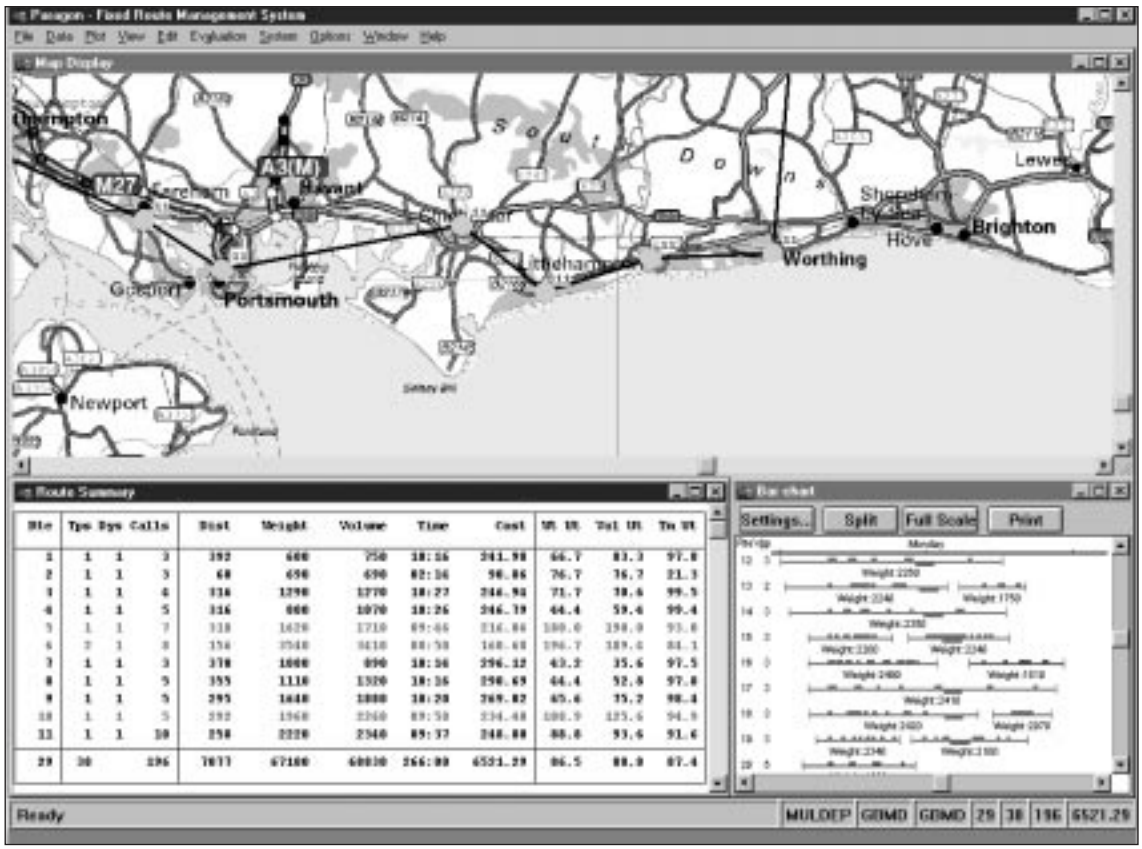


Fig 10 Example of route bar chart summary

7 SELECTING A CVRS SYSTEM

Before choosing a CVRS system the potential user should:

- identify whether there is a need for some kind of CVRS;
- identify the type likely to be the most appropriate (i.e. journey planner or vehicle scheduling system);
- establish how the CVRS system could be integrated with existing systems;
- decide who will be responsible for its implementation, use and maintenance;
- evaluate alternatives;
- conduct operational trials back to back with the current system.

The key steps set out in Fig 11 should always be followed when selecting a CVRS system.

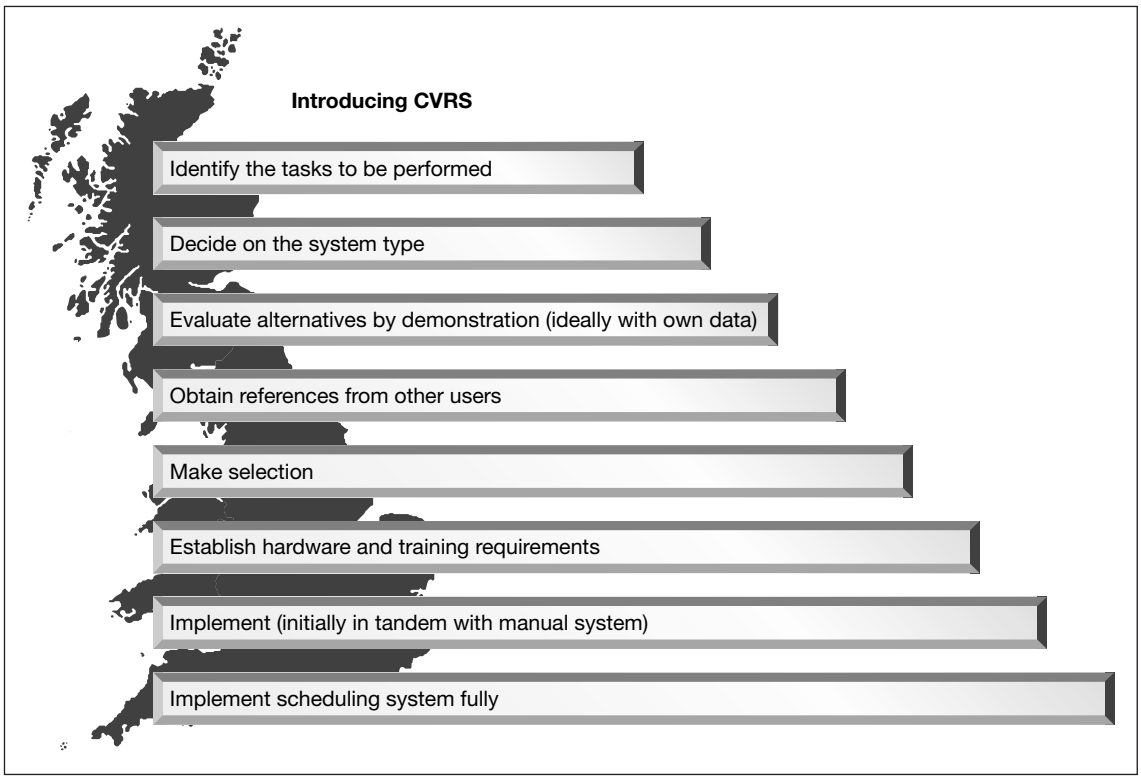


Fig 11 Flow diagram of selection process

The best way for an organisation to establish if there is any potential for securing the benefits of CVRS is to make an assessment of the operation by comparing results obtained for a sample activity period using its own operational data.

Evaluate and compare at least three products that offer the features you are seeking.

For maximum benefit, it is essential that all parts of the organisation that are likely to be affected by the introduction of CVRS are fully briefed regarding the system and how they can contribute towards its success. Commitment must come from the top down, so it is vital that the person within the organisation who can take the ultimate decision regarding CVRS implementation fully understands the benefits.

7.1 Support training and development

The system must work well and must be well supported by the software supplier. All functions of the system must be tested before purchasing the software.

Particular attention should be paid to the data importation process, as the methods of data transfer vary considerably from system to system.

Potential users should also:

- examine the company's training programme to establish how long it will take to train users and the level of computer knowledge that will be required of the staff that will use the system;
- study the terms of the annual maintenance agreement to establish frequency of updates and the method of their dissemination;
- talk to other users of the systems being considered to establish their experience of the software (good and bad).

Armitage Shanks

Armitage Shanks supplies and delivers bathroom furniture through eight depots, the central distribution being controlled through one main depot. The manual process for organising the vehicle routing and scheduling was via a pigeon hole method. This process used to take two planners one day to plan the routes.

It was decided that in order to operate on a more efficient and cost effective basis, Armitage Shanks should look at incorporating a CVRS system with its SAPS system. The company looked at various packages with a view to embedding the CVRS package with its internal system. It introduced Optrak 3 on a pilot scheme along side the original system, for a trial period, before going live around three or four years ago. Although a few initial problems were encountered in the trial stage, these were overcome before the system went live. Armitage Shanks considers that the system was the correct solution.

With savings of £600,000 since the introduction of CVRS, other benefits include:

- creativity and flexibility;
- improvements in vehicle capacity;
- time window improvements;
- cost improvements;
- overall distribution efficiency – fully appreciated and understood;
- palletise information;
- streamline vehicle operation.

The following checklist of points to consider may be useful:

- Is support from the software provider available 24 hours a day if required?
- Is support available on line?
- Is the CVRS system continually being developed and enhanced?
- How often are updates issued? Too great a frequency may suggest the product is unreliable and subject to excessive rectification.

- Does the supplier provide bespoke enhancements for any specialised activities such as multiple product tanker operations and multiple temperature distribution with movable compartment bulkheads?
- Is the system competitively priced?
- Can the system be leased?
- Can the system adapt and keep pace with the developments planned within your company?
- Is the system capable of readily interfacing with other software in use or under consideration (e.g. order processing and warehouse management)?
- Are maps provided for all European countries where the organisation operates?
- Does the supplier provide a software manual and comprehensive easily understood help screens?

The Government's Energy Efficiency Best Practice Programme provides impartial, authoritative information on energy efficiency techniques and technologies in industry, transport and buildings. This information is disseminated through publications, videos and software, together with seminars, workshops and other events. Publications within the Best Practice Programme are shown opposite.

Further information

For buildings-related topics please contact:

BRECSU
Building Research Establishment
Garston, Watford, WD2 7JR
Tel 01923 664258
Fax 01923 664787
E-mail brecsuenq@bre.co.uk

For industrial and transport topics please contact:

ETSU
Harwell, Didcot, Oxfordshire,
OX11 0RA
Fax 01235 433066
Helpline Tel 0800 585794
Helpline E-mail etbppenvhelp@aeat.co.uk

Energy Consumption Guides: compare energy use in specific processes, operations, plant and building types.

Good Practice: promotes proven energy efficient techniques through Guides and Case Studies.

New Practice: monitors first commercial applications of new energy efficiency measures.

Future Practice: reports on joint R & D ventures into new energy efficiency measures.

General Information: describes concepts and approaches yet to be fully established as good practice.

Fuel Efficiency Booklets: give detailed information on specific technologies and techniques.

Energy Efficiency in Buildings: helps new energy managers understand the use and costs of heating, lighting etc.